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(56) Documents Cited:

GB 2345538 A	EP 0587138 A2
WO 2002/027453 A2	US 5616078 A
US 5454043 A	US 5297061 A

(58) Field of Search:

Other: EPODOC, JAPIO, WPI

(54) Abstract Title: Input or pointing device with a camera

(57) A pointing device having a moveable 3-D shape form 1 with bold visual features 2 is imaged by a television camera 3 to obtain a 2-D electronic image. The electronic image is evaluated by means of computer software in order to extract the visual features and measure their spatial dispositions within the 2-D image. This information enables six degrees of movement of the device to be determined. The movement so determined is applied to a 2-D graphical representation of a virtual 3-D image displayed on a viewing screen of a computer monitor 5, or used to provide pointing information. The shape form 1 may be a cube, sphere (fig 4) or polyhedron (fig 3) with different coloured regions or LED's, or merely an assembly of LED's or the users hand; may be mounted on a base (figs 5-7); or enclosed by a transparent mouse type cover. A second camera (fig 8) may be provided for eclipsed or awkwardly lit features 2.

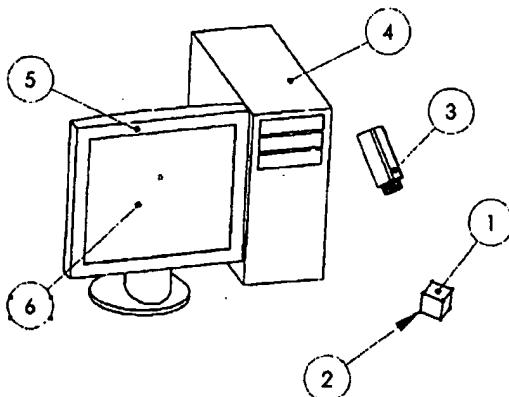


Figure 1

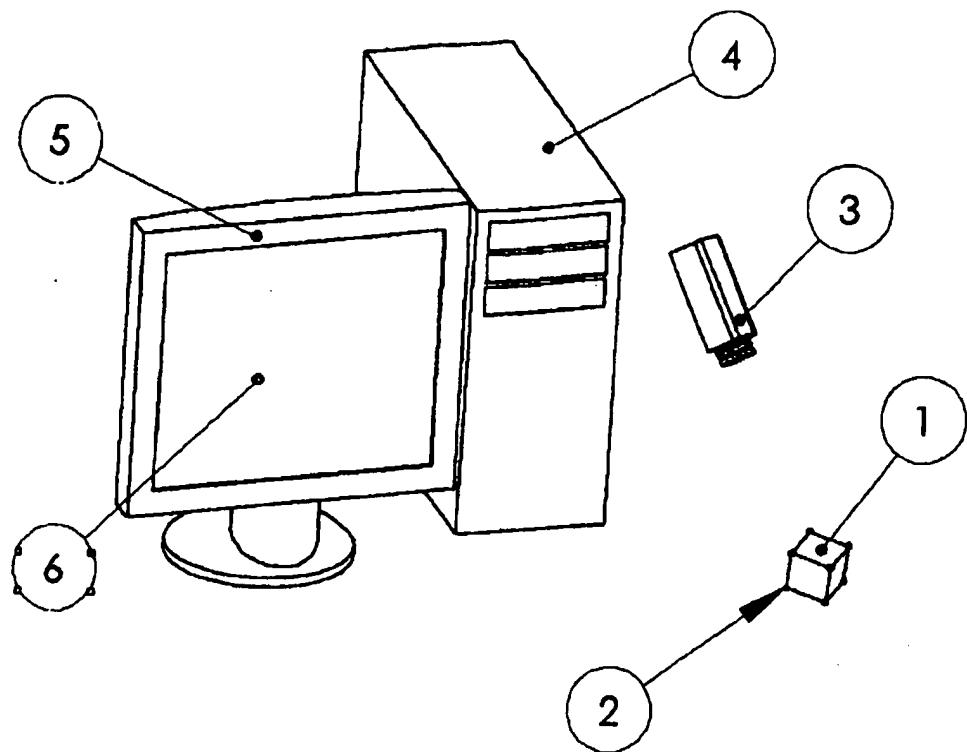


Figure 1

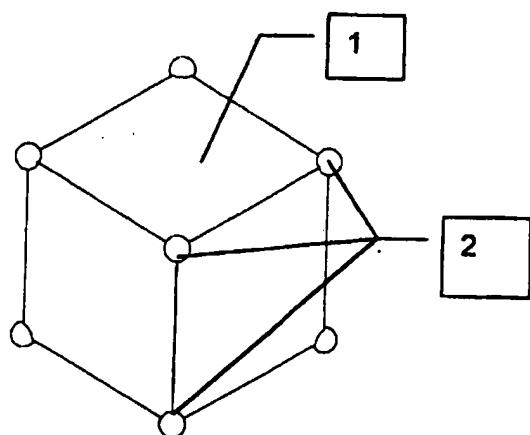


Figure 2

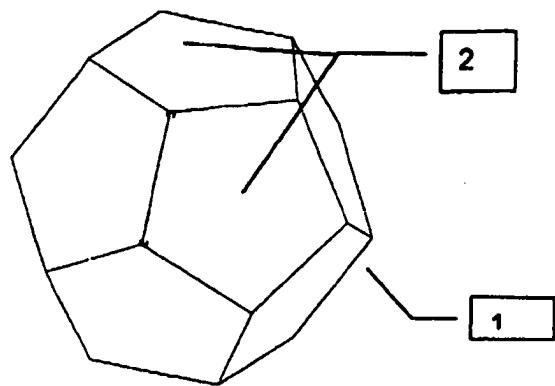


Figure 3

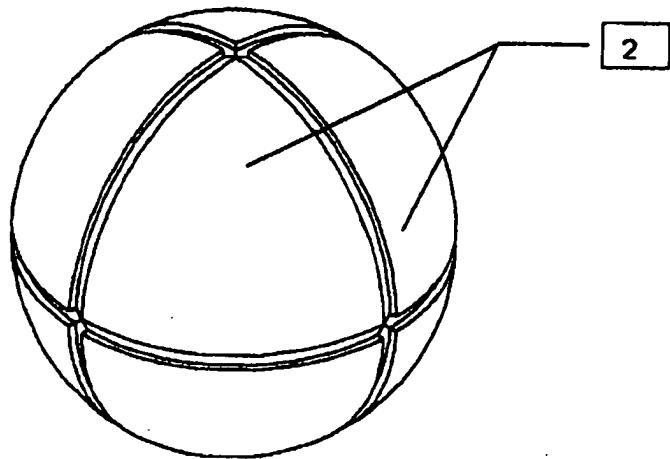


Figure 4

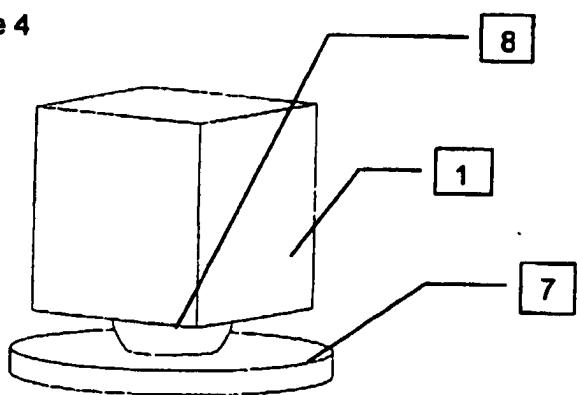


Figure 5

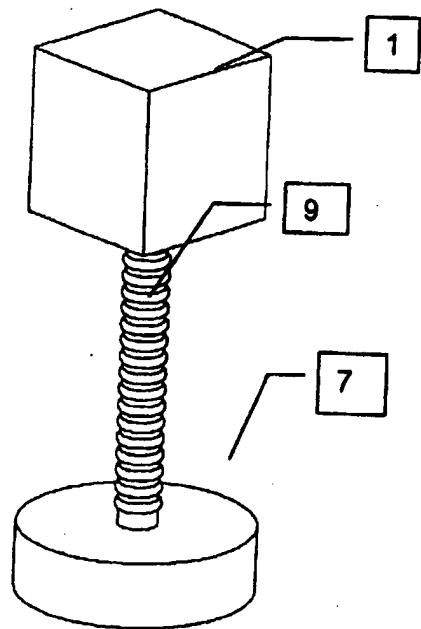


Figure 6

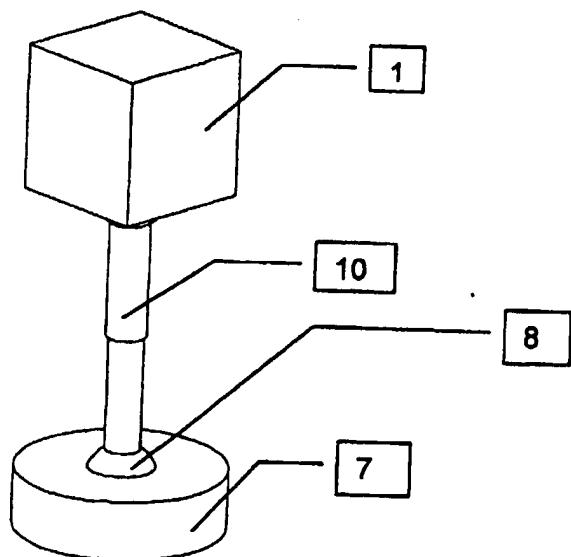
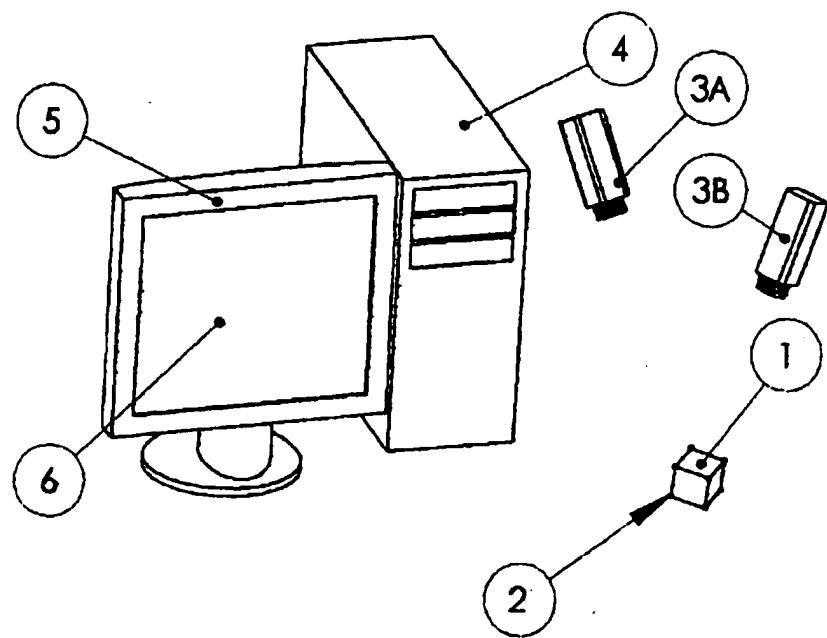


Figure 7



**Figure 8**

## Multi-vector pointing device

The present invention is an extension of conventional forms of mouse in common usage with personal computers (PCs). PC mice, trackballs and touch pads provide two degrees of freedom while some joysticks or 'spaceballs' provide three or more degrees by incorporating a rotation as well as linear action.

An objective of the present invention is to facilitate the representation of six degrees of freedom of movement of a 3-D object when displayed on a 2-D display screen. Six degrees of freedom are provided by three (x, y and z axes) translation directions and three rotational movements about those axes.

The closest prior art are so called "spaceballs" (for example from IBM), which are commercially available, and are able to provide up to six degrees of freedom. These are expensive and unwieldy to use. In use, it is difficult to maintain independent control of the degrees of freedom, using a "spaceball". It is an objective of the present invention to overcome these difficulties.

Conventional PC mice, while only providing two degrees of freedom, are also prior art for the present invention.

It is further an objective of the present invention to facilitate the representation of six degrees of freedom of movement of a 3-D object, when displayed on a 2-D display screen, using existing low cost hardware.

PC mice are used with solid computer modelling software to effect on-screen movement of 2-D pictorial representation of 3-D computer generated designs. Visual 2-D representation of all six degrees of freedom is difficult to portray using a 2-D device such as a computer mouse.

It is an objective of the present invention to provide up to six substantially independent degrees of freedom, which can be translated into corresponding degrees of freedom in a 2-D representation of a 3-D image, in a readily useable ergonomic form.

In the present invention, a requisite number of independent degrees of freedom are derived from a 2-D optical image of a 3-D shape form. This is effected by converting the optical image into electronic form by existing known means, such as a charge coupled device (CCD) camera, and evaluating the electronic image in a way to determine movement in any of the six degrees of freedom. The present invention provides for any of the derived degrees of freedom to be appropriately applied to a virtual 3-D image displayed on a 2-D display, for example on a PC monitor. This enables an operator to manipulate the movements of a displayed image in a precise manner by virtue of the normal biofeedback loop translated through the operator.

The evaluation of the electronic image is performed by appropriate computer software, which, when written is inexpensive to replicate and may be installed on any PC.

According to the present invention, there is provided a multi-vector pointing device comprising a moveable shape form, a camera for producing a 2-D electronic image of the shape form in real time, characterised in providing pointing or viewing information of the object for software applications.

According to the present invention, there is provided a multi-vector pointing device comprising a moveable three dimensional (3-D) shape form, a camera for producing a two dimensional (2-D) electronic image of the 3-D shape form in real time, characterised in providing evaluating means for determining up to six degrees of freedom of the 3-D shape form from the 2-D electronic image of the 3-D shape form and appropriately applying the degrees of freedom to a 2-D representation of a general virtual 3-D image displayed on a viewing screen.

Within the context of the present invention, the term "shape form" is used to describe an imagable multivector pointing device represented in three spatial dimensions. The shape form may also have two dimensional form, such as when constructed from a planar material such as sheet material, but would still occupy three dimensional space.

Central to the invention is the use of a television camera, typically using CCD technology, for providing a 2-D image of a 3-D shape form, in electronic form. The 3-D shape form provides visual features whose positions are determined from the 2-D electronic form of the image. There are provided a sufficient number of visual features to determine the required number of degrees of freedom: for example three are required to produce six degrees of freedom, while two degrees of freedom may be determined from a single point feature.

Evaluation of the positions of visual features in a 2-D electronic form of the image is performed in a prescribed way according to rules contained in computer software. This determines the directions and magnitudes of three orthogonal translations and three orthogonal rotations of the 3-D shape form.

The visual features provided on the 3-D shape form (forming part of the 3-D shape form) can be made distinctive, for example with coloured spherical surfaces, positioned in a suitable geometrical arrangement. Coloured spherical surfaces may be positioned at the corners corresponding to the corners of a cube. It is within the scope of the present invention to provide a 3-D shape form having distinctive visual features disposed in any geometrical or non-geometrical 3-D configuration, suitable for facilitating their evaluation. Any particular configuration of visual features constitutes part of a 3-D shape form.

Any means of providing visually distinct features lies within the scope of the present invention. This includes: polished or matt balls (spherical surfaces) illuminated by external light source; and small emitting regions such as light emitting diodes (l.e.d.s); small white, coloured or reflective stickers placed on the surface of a shape

form. The distinctive visual features will normally be attached to a featureless handheld rigid body, painted in one colour different from any of the visual features. For example, the body may be matt white or black, or any colour which is conveniently separated by electronic means in the 2-D electronic image.

It is also within the scope of the present invention to include visual features on a 3-D shape form that are present by virtue of the geometry of the shape form, and which are highlighted by any given mode of illumination, such as room lighting.

It is convenient that the distances separating pairs of visual features are pre-determined for use by the evaluating algorithms in the software. This is especially appropriate when the visual features are disposed according to a distinctive geometrical shape such as the corners of a cube. This, however, is not a prerequisite, and the necessary spatial information about the visual features may be determined using software based teaching procedures known per se. This is especially useful when the 3-D shape form has arbitrary shape with arbitrary visual features identifiable from a 2-D image of the shape form.

While the 3-D shape form is primarily intended to be a handheld device, which replaces a computer mouse, it may be designed for use by disabled persons. It could for example be constructed from light weight materials, such as table tennis balls, which may be manipulated by a mouth held probe.

It is within the scope of the present invention to include a user's hand or clenched fist as a 3-D shape form. Paper stickers may be attached to an operator's hand to provide easily identifiable visual features.

It is also within the scope of the invention to provide evaluation software which will determine any of the six degrees of movement freedom of an arbitrary 3-D shape form (such as a clenched fist), by automatically identifying and tracking prominent visual features present in the shape form. This relies on measuring different amounts of displacement, between different visual feature pairs, detected in the 2-D

electronic image. In this embodiment it is prudent to incorporate redundant information (redundant visual features) not only to improve accuracy, but also to cope with features coming in and out of prominence as the 3-D shape form rotates.

Standard imaging processing techniques, known in the art, may be used in identifying visual features for the purpose of evaluation. By way of example, one method of evaluation involves computing the 2-D coordinates of centroids of respective visual features. Dimensions between all pairs of respective centroids are calculated, and variations in these values are used to determine movement in all six degrees of freedom. Many image processing and pattern recognition algorithms are known in the art, for the purpose of feature extraction, many of which are applicable to the present invention. For example edge detection may be used to identify closed regions. For the purpose of this invention, a convenient number of closed regions may be selected and their centroids computed.

Tracking algorithms may be employed which correctly identify visual features as their shapes change with movement. Previously documented processing techniques may be applied in this invention for the purpose of achieving the desired result.

Movement in any of the six degrees of freedom of the 3-D shape form is computed solely from distance-vector measurements made between visual features in the 2-D image and rates at which these distance-vectors change. Computation is simplified if actual distances between features is known in advance, but this is not a prerequisite for successful operation.

It is also within the scope of the invention to provide more than one camera for viewing a shape form. This provides redundancy of information useful in circumstances when a feature is eclipsed from view by the shape form, or when lighting favours one viewing direction over another.

The invention is described in detail with reference to the following figures:

Figure 1 shows salient features of a preferred embodiment of the invention.

Figures 2 shows a shape form in the shape of a cube.

Figure 3 shows a shape form in the shape of a regular solid polygon.

Figure 4 shows a shape form in the shape of a sub-divided sphere.

Figure 5 shows a shape form attached to a base via a ball joint.

Figure 6 shows a shape form attached to a base via coiled spring.

Figure 7 shows a shape form attached to a base via an extendable stalk and ball joint.

Figure 8 shows an embodiment of the invention using two television cameras.

With reference to figure 1: shape form, 1, supporting at least one visual feature, 2, is imaged by television camera, 3, to produce a 2-D electronic image. This electronic image passes into PC, 4, for evaluation by image evaluating software. The image passes into the PC by known means, for example via a universal serial bus (USB) port. The television camera may conveniently be a "webcam" type.

Monitor, 5, displays a 3-D representation of any object, 6, which has been created or forms part of any software application using 3-D representation.

The 3-D representation of object, 6, is moved on the monitor screen in any of the 6 apparent degrees of freedom attributed to a three dimensional object, by imparting appropriate corresponding movement to shape form, 2. It will be appreciated that the 3-D representation of object 6, is actually a 2-D image on a flat screen.

Movement in any of six degrees of freedom are therefore apparent movement in the 3-D representation which enhance the 3-D perception of the object.

Figure 2 shows a shape form with bold visual features, 1, positioned at the corners of a cube. In this case the visual features are partial spherical surfaces which may be polished metal to reflect external light sources, or else coated black, white or different colours, in matt or any other suitable surface finish. The features, 1, positioned at the corners of cube, 2, may equally be emitting light sources such as light emitting diodes (l.e.d.s). Different coloured l.e.d.s can be used to facilitate feature detection and identification.

Figure 3 shows a regular 12 sided shape form having pentagonal faces. The faces themselves may be coloured to provide visual features or features may be attached to the corners as described above with reference to figure 2. The present invention is not restricted to this particular multifaceted shape form and any similar, not necessarily regular, multifaceted object may be used in accordance with the present invention.

Figure 4 shows a spherical shape form, subdivided into distinct regions. The regions provide visual features, which may be coloured to facilitate identification.

Figure 5 shows a shape form, mounted to a base, 7, via a ball-joint, 8. This allows the shape form to move in two horizontal dimensions as well as rotation about three perpendicular axes. The shape form is normally moved by hand, and a handle may be provided to assist hand movement.

Figure 6 shows a shape form with movement in all six degrees of freedom. The shape form, 2, is attached to a base, 7, via a loose coil, 9, which allows the shape form to be moved vertically as well as rotated about three orthogonal axes, relative to the base. The base is moveable in two horizontal axes; also the shape form is moveable in two horizontal axes relative to the base.

Figure 7 shows another way in which the shape form is moved in six degrees of freedom. The shape form is attached to a base, 7, by an extendable stalk, 10, via pivots or a ball joint, 8. The base is moveable in two horizontal axes; also the shape form is moveable in two horizontal axes relative to the base.

Any shape form may be attached to a base in accordance with figures 5, 6, and 7 or by other means.

Figure 8 shows an embodiment of the invention incorporating more than one television camera. This provides redundant information, which is needed in cases where visual features become indistinct, such as when the shape form is an arbitrary shape.

Any appropriate arbitrarily shaped object can be used as a shape form in accordance with the present invention. This includes an assembly of l.e.d.s without a regular geometrical relationship between them.

The present invention includes a visual feature set and/or shape form, enclosed by a transparent mouse, type, cover. This provides aesthetic appeal, and the cover may be fashioned as a handle for ease of use. The cover can, for example, be dome shaped moulded transparent plastic.

Included within the scope of the present invention is a shape form attached to a base via any semi-flexible coupling material, which allows complete freedom of movement of the shape form, but remains in a fixed position when released.

Those skilled in the art will appreciate that while the present invention can return information about six degrees of freedom it could also be used to return less information, and therefore replace joysticks (normally three degrees of freedom) and mice (normally two degrees of freedom).

## Multi-vector pointing device

### CLAIMS:

1. According to the invention, there is provided a multi-vector pointing device comprising a moveable shape form, a camera for producing a 2-D electronic image of the shape form in real time, characterised in providing pointing or viewing information for software applications.
2. According to the invention, there is provided a multi-vector pointing device comprising a moveable three dimensional (3-D) shape form, a camera for producing a two dimensional (2-D) electronic image of the 3-D shape form in real time, characterised in providing evaluating means for determining up to six degrees of freedom of the 3-D shape form from the 2-D electronic image of the 3-D shape form and appropriately applying the degrees of freedom to a 2-D representation of a general virtual 3-D image displayed on a viewing screen.
3. A multi-vector pointing device according to claims 1 or 2 wherein the moveable shape form supports and provides visual features.
4. A multi-vector pointing device according to claim 3 wherein the number of supported visual features is at least three.
5. A multi-vector pointing device according to claims 1 or 2 and 3 wherein the number of supported visual features is sufficient for at least three of the visual features to be distinct in the 2-D electronic image of the shape form at all times during operation.

6. A multi-vector pointing device according to claim 5 wherein visual features are rendered distinctive by virtue of visual features being of different colours.
7. A multi-vector pointing device according to claims 5 or 6 wherein visual features are disposed in any suitable geometrical 3-D configuration.
8. A multi-vector pointing device according to any of the claims 5, 6 or 7 wherein the visual features are rendered distinctive by virtue of being individual spherical surfaces having polished or matt surfaces and which are illuminated by an external light source.
9. A multi-vector pointing device according to any of the claims 5, 6 or 7 wherein the visual features are rendered distinctive by virtue of being individual light emitters.
10. A multi-vector pointing device according to claim 9 wherein individual light emitters are light emitting diodes.
11. A multi-vector pointing device according to any one of claims 3, 4, 5 or 7 wherein visual features are white, coloured or reflective stickers placed on the surface of a shape form.
12. A multi-vector pointing device according to any of the previous claim wherein the shape form is a handheld rigid body.
13. A multi-vector pointing device according to claim 12 wherein the shape form is a 3-D polyhedron.
14. A multi-vector pointing device according to claim 13 wherein the facets of 3-D polyhedron are visual features.



Application No: GB 0207300.5  
Claims searched: 1 & 2 at least

Examiner: Terence Newhouse  
Date of search: 4 September 2003

## Patents Act 1977 : Search Report under Section 17

### Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance	
X	1 & 2 at least	US 5297061	(Maryland), see for example abstract
X	1 & 2 at least	EP 0587138 A2	(Kabushiki), see for example abstract and figures 2 & 3
X	1 & 2 at least	WO 02/027453 A2	(Bustamante), see whole document
X	1 & 2 at least	GB 2345538 A	(James), see for example abstract
X	1 & 2 at least	US 5616078	(Konami), see whole document
X	1 & 2 at least	US 5454043	(Mitsubishi), see for example figure 1

### Categories:

X Document indicating lack of novelty or inventive step	A Document indicating technological background and/or state of the art.
Y Document indicating lack of inventive step if combined with one or more other documents of same category.	P Document published on or after the declared priority date but before the filing date of this invention.
Q Member of the same patent family	E Patent document published on or after, but with priority date earlier than, the filing date of this application.

### Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC<sup>v</sup>:

Worldwide search of patent documents classified in the following areas of the IPC<sup>7</sup>:

The following online and other databases have been used in the preparation of this search report:

EPODOC, JAPIO, WPI